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IN TWO SECTIONS

Section I

N.A.C.A. LIBRARY

IN THIS ISSUE

Controlling Tool Costs, by Sidney R. Catsiff 1149

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EDITORIAL DEPARTMENT NOTE

Industrial accountants have at times been criticized on the ground that they know too little about production problems, that they tend to do their accounting in the office without sufficient knowledge or understanding of what is taking place in the plant. To the extent that this criticism is justified it may indicate a shortcoming in our educational program for accountants, with too much emphasis in our schools of business, so far as students of industrial accounting are concerned, on the strictly financial phases of accounting without sufficient consideration of the engineering aspects of industrial accounting. Most cost accountants who have received their training in schools of business or accounting have had to acquire their familiarity with plant and production techniques and problems in the school of experience and through extra-curricular reading. To those who need more background and understanding of this field, the article in this issue of the *Bulletin* should prove most helpful. The control of tool costs is to a considerable extent an engineering problem, but one in which the industrial accountant with the proper background can contribute much.

Sidney R. Catsiff, the author of this article, is a graduate of the University of Pennsylvania, having studied both Electrical Engineering and Industrial Management there. In 1927 he entered the employ of the General Electric Co. at their Philadelphia Works and after serving in several capacities there was promoted to the staff of the Supervisor of Costs in the General Electric office at Schenectady. In 1939 Mr. Catsiff was appointed Supervisor of Costs for the Fort Wayne Works, and recently was promoted to the Staff of the Works Manager. For the current year he has been serving as Director of Program for the new Fort Wayne Chapter.

Articles published in the *Bulletin* present many different viewpoints. In publishing them the Association is not sponsoring the views expressed, but is endeavoring to provide for its members material which will be helpful and stimulating. Constructive comments are welcomed and will be published in the Forum Section of the *Bulletin*.

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NATIONAL ASSOCIATION OF
COST ACCOUNTANTS

MAY 15, 1940

CONTROLLING TOOL COSTS

By Sidney R. Catsiff, Staff, Works Manager,

General Electric Co., Fort Wayne, Ind.

What Are Tools?

SOUNDS simple, doesn't it? You can probably name hundreds of tools, but as you start running them over in your mind you find that in its broadest interpretation, a tool may range anywhere from a dressmaker's pattern or a kitchen knife to an enormous die for forming the top of an automobile body. It may mean a machine tool for drilling several holes in a motor end shield at one handling, or only a carpenter's hammer.

For this discussion, however, we are going to restrict ourselves to what may be called Engineering Patterns. Let us define them as patterns, molds, jigs, punches, dies and other small tools, attachments, and fixtures designed for specific products, the use of which is dependent upon a continuation of the practice under which they are employed.

Importance of Tools

Each year as industry becomes more mechanized, increasing expenditures are made for tools, and it is important that we as cost accountants know how to insure that such expenditures are economically made.

In addition to the actual amount of money spent for tools, which itself offers a great opportunity for saving, it should be remembered that the correct use of tools offers an outstanding aid to reduction of production costs and improved products.

Classification of Tools

Below we are listing the main types of tools and some of the commonly used shop terms, together with their most generally accepted meaning.

PATTERNS —Wood or metal replicas of a part to be made as a sand casting. The pattern is used to form a cavity in the sand into which metal is poured to form the desired shape. It may be single or multiple, that is, it may be used for casting one or several parts at a time.

MOLDS —Usually a metal cavity into which materials are poured or pressed to obtain desired shapes.

1. Plastic molds—for rubber, Textolite, Bakelite, etc.
2. Porcelain molds—for moldable ceramic products.
3. Die casting molds—for aluminum, zinc, lead, etc.
4. Forging molds—more usually called "dies."

FIXTURES —A means of holding or positioning work.

1. Welding fixtures—to position and hold work preparatory to welding.
2. Milling fixtures—to hold work which, because of its shape, is not easily held by the standard milling machines vises.
3. Assembly fixtures—to hold parts as an aid to assembly operations.
4. Riveting fixtures—to hold parts together while being riveted.
5. Various types of holding jaws or chucks for automatic lathes, boring machines, grinders, etc.

JIGS —This word is sometimes used synonymously with "fixtures," more generally it means a fiixture for drilling. It holds work and furnishes a means of quickly and accurately positioning drills at desired places on work and determines the relationship of one hole to another.

1. Simple plate drill jigs—for flat pieces or surfaces.
2. Box jigs—the work is enclosed by the jig; usually used for irregular shaped parts or where drilling from several directions is desired.
3. Trunion jigs—a form of box jig for heavy work to aid in quickly turning over the work to drill from several directions.

TEMPLATES —Usually a thin sheet of metal, paper, or cardboard to be used for marking out irregular shapes or positions of holes.

1. Layout or drill templates—for spotting through or marking position of holes to be drilled, also used as a pattern for marking outlines of irregular shaped parts.
2. Oxygraph templates—to serve as a pattern for marking outline of parts to be burned with oxyacetylene flame. In some cases it guides a tracer wheel which in turn, by means of a pantograph arrangement, directs the movement of the burning torch.
3. Contour templates—used to check roughly whether or not sufficient material has been removed from an irregularly shaped contour.

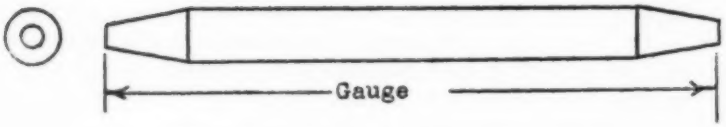
DIES —Usually refers to tools for the cutting, forming, or drawing of sheet materials. In some cases this definition does not hold and some examples of other types are given below.

1. Blanking and piercing dies—for cutting holes in, or trimming the outside of, parts made from sheet materials. Piercing usually refers to small holes, while blanking means larger holes and outside cutting. Quite often a die will do both, that is, blank and pierce.
2. Forming dies—might better be called bending or folding dies. Sometimes operation of forming may be combined with blanking and piercing, that is "blank, pierce and form" in one die.
3. Drawing dies—for stretching sheet materials into cup-like shapes. Sometimes done in combination with blanking and piercing operations, that is "blank, pierce and draw."

4. Wire drawing dies—a series of tool steel pieces with gradually decreasing holes for reducing or changing the size or shape of wire.
5. Coining dies—a die which changes the thickness of sheet material by means of pressure in a punch press. Example: hard money, medals, etc.
6. Forging dies—cavity in steel into which metals are forced by means of blows from hand hammers or mechanical drop hammers. This work is usually performed with the addition to heat to allow the material to flow more easily and take the shape of the cavity in the die.
7. Heading dies—used on heading machines which upset wire to form heads on parts. Work may be done hot or cold.
8. Die casting dies—See Molds.

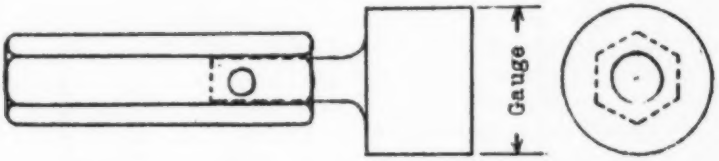
GAUGES —A means of measuring or checking accuracy of work. May be an indicating or measuring type or merely a means of comparing with a desired standard. Below we are showing an example of the most simple type under each heading.

1. Pin gauge—for size control of holes of a large diameter.

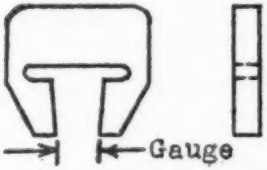


2. Plug gauges—for size control of holes of a small diameter. Five inches is the maximum diameter recommended. May be used up to 10 inches only for surface contact.

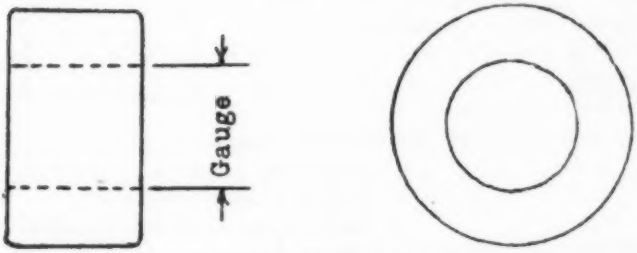
On 6 to 10 inch diameters, pin gauges should be used for point-to-point contact.



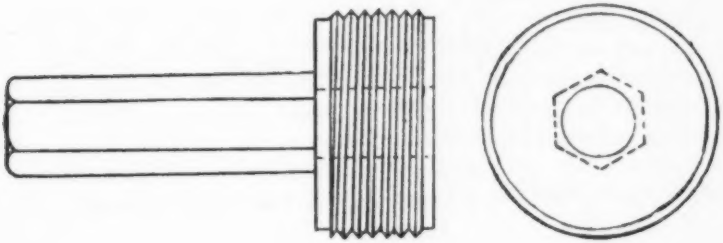
3. Snap gauges—for control of outside measurements or thicknesses.



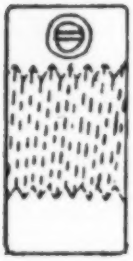
4. Ring gauges—for small outside diameters.



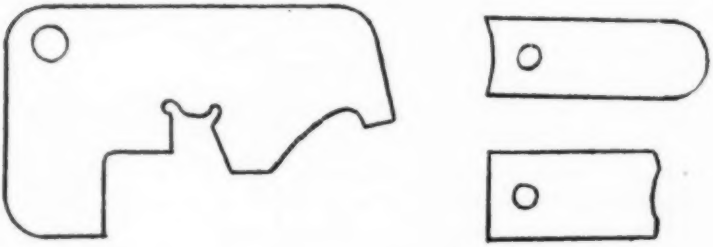
5. Thread plug gauges—for internal threads.



6. Thread ring gauges—for external thread.



7. Radius and profile gauges—for checking radii or profiles.



8. Miscellaneous Gauges—such as:
   a. Alignment,
   b. Various types of indicators,
   c. Various types of electrical gauges,
   d. Thickness gauges,
   e. Key-slot gauges, etc.

MISCELLANEOUS —This includes an endless variety of aids to the mechanical working of materials. Below we list just a very few of them:

1. Reamers,
2. Boring bars,
3. Forming tools for screw machines,
4. Cams for various types of automatic machines,

5. Spinning forms,
6. Broahces,
7. Winding forms, etc.

Selection of Tools

The selection of the type and design of tools required is usually the joint responsibility of the tool department and the planning engineer. However, this does not mean the designing engineer does not have an important part in the work, because he definitely has, and we will now discuss the contributions he can make.

Selection of tools may be divided into several parts, such as:

When are tools needed?
What type of tools should be used? (What is the expected production of the part? . . . etc.)
What tools are already available?
What changes in the design of the part can be made to simplify or improve tool construction?

These factors will be considered in the following example.

Hereafter in our discussion, the word "tools" will mean special engineering patterns and tools as listed above, and not standard tools, such as drills, turning tools for lathes or boring machines, etc. Keeping this in mind, we can say that almost without exception we can get a mechanic to make any part in our apparatus without special tools, so that it will function to the satisfaction of the engineer. This may sound strange but let us look at an example to illustrate this point.

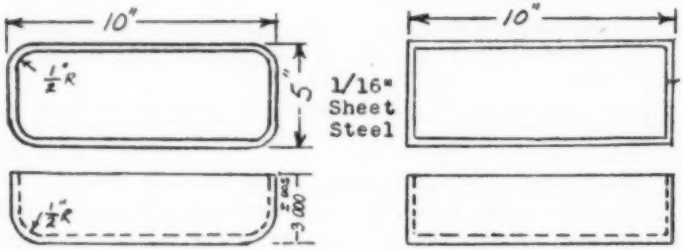
Use of Hand Tools

Suppose we require a sheet metal drawn cover of the type which encloses many electrical devices. It is to be 1/16" thick and any size we desire; let us say 8" wide by 10" long by 3" deep. To make it difficult, we specify nicely rounded corners. We have restricted our mechanic to the use of his hands, the standard machine tools and supply of drills, turning tools and hand tools which are in any well-equipped machine shop. We have told him that we won't spend a penny for dies to draw the cover or for any other special tools, as we desire only one or two of them.

Our mechanic says it would be easy if we didn't want those

round corners, because all he would have to do then would be to take a sheet of metal and cut it to size on a shear if available, or use a hack saw if not, cut out notches in the corners with that same hack saw, bend the sides up by beating them with a hammer against the side of some steel block he has lying around, weld up the edges where they meet and then clean up the rough spots with a file.

But we said "round corners," didn't we? Well that's much harder and will cost more. In this case, he will probably have to use two pieces of sheet metal, one for the sides and the other for the bottom. First he takes the long strip of metal and bends it to



The cover we have designed.

The cover our mechanic would prefer making by hand.

form the sides, welding along the edge. Of course, to get the round corners he probably will have to mill or shape up a radius on one edge of that steel block he used before so as to obtain the nice round edges we want. Well, now he has the sides and rectangular piece of steel for the bottom but no round edges where they meet. He then cuts a little notch with his handy hack saw in each corner of the side piece, and forms in the bottom edges by beating against that same block he used before to obtain the desired radius. After hacking and filing the bottom piece to fit the side piece, he welds them together, not forgetting to fill in the open hole at each corner, where he didn't fit the pieces together very well. If necessary, he may even have to fit a small piece into each corner before welding. Then a file to smooth up the irregularities, and we have our box all ready for use.

Of course, all this hand work was slow and cost a lot of money, possibly fifteen to twenty dollars, but if we need only one or two such covers, we cannot afford to spend the thousand dollars required to make blanking and drawing dies.

Problem Varies with Quantity Desired

Now let us suppose we need a hundred such cases. We figure up—100 × $15 = $1,500 and we decide we can afford those dies now. But wait a moment; haven't we forgotten something? That's right, the cost of the boxes if we had the dies. Five cents a piece, we find out from the planning department, times the hundred boxes we require is $5 for the lot, so we are still right, and we are ready to sign the tool order. But just as we are about to say, "Go ahead," we think, "It cost fifteen dollars for that one cover our mechanic made, but he had to do a lot of cutting and fitting to get those corners to fit together. Wonder whether he couldn't better that on a hundred?" Our mechanic tells us that he can't better that fifteen dollar figure very much, but if we would loosen up a little and spend about a hundred dollars for some simple tools, he could make that case for five dollars. On further inquiry we learn that he needs a template for laying out the sheets so he won't have to cut and try each box, and a die for the "Cincinnati brake" (a machine for forming sheet metal) to eliminate the hammering by hand. Our costs now figure like this:

No. 1—100 x $15 = $1,500 plus 0 tools = $1,500 total
No. 2—100 x $ 5 = $ 500 plus $ 100 tools = $ 600 total
No. 3—100 x 5¢ = $ 5 plus $1000 tools = $1,005 total

Our mechanic in this case obtained his hundred dollars for the tools.

Suppose, however, we need a thousand covers instead of a hundred, our cost figures would then be:

No. 1—1000 x $15 = $15,000 plus 0 tools = $15,000 total
No. 2—1000 x $ 5 = $ 5,000 plus $ 100 tools = $ 5,100 total
No. 3—1000 x 5¢ = $ 50 plus $1,000 tools = $ 1,050 total.

Obviously, we no longer hesitate in sending that order through to the tool department.

The next day, however, a wide awake tool designer stops in to see us and inquires if we could have the engineer change our design and make the cover 1/8" longer, because if we can, he has a die already in production which can make our cover with a very

few changes and save us almost the entire thousand dollars. Our engineer says "Sure, I can do that, by making the corresponding change in several other related parts, but there's the snag—we have already released the tools for these other parts and the tool department is working on them." On investigation, the loss entailed in changing them over exceeds the saving we can make and sorrowfully we go ahead and making that $1,000 die. We found out about the other die too late.

But the tool designer's trip over to see us was not in vain, because in talking to the engineer he did learn just where this cover was used and questioned why we showed such a close tolerance on the depth of the cover. "Close tolerance?" the engineer asked. "Plus or minus 0.005" isn't close tolerance. Why, we have always understood that dies made parts closer than that without any trouble at all, so what are you kicking about?" The tool designer explains that he isn't kicking, but if we can allow plus or minus 1/8" he can save a trimming operation after drawing, which will save us about $200 and also eliminate a labor operation. Our engineer has no argument on that and gladly agrees to the change, but tries to justify the plus or minus 0.005" tolerance being on the drawing with a remark to the effect that "It's O.K. this time but I don't like to give you fellows too much leeway, as the first thing I know you'll be getting careless and making us poor tools."

The Secret of Lower Tool Costs

The above somewhat lengthy story has hidden in its ramifications a number of points that we, as cost accountants, should take a lesson from, since they hold the secret of lower tool costs. We will now summarize them so that you can check them against your own reactions to this story.

1. *Tools are not a necessity, but an investment* and must show savings to justify their cost. In many cases, of course, the savings by their use are so great that we have come to the stage where we consider them necessities.

In some cases, tools may not be justified by the saving in production cost, but due to accuracy requirements or scarcity of mechanics who can be depended upon to work without tools, it may be advisable to make the tools.

Exhibit 1 shows a representative tool authorization form which provides a space for recording the calculations necessary before deciding upon the economy of a certain tool.

FOR { REQ'N / MFG. ORD.

SHOP ORDER REQUEST

S.O.

PROD. DWG.	REQUESTED BY	ISSUE TO

CLASS OF WORK—CHECK		PROD. REQUIREMENTS		ESTIMATED COST	
ENG. TOOL OR PATT.—NEW	☐	MAXIMUM WEEKLY LOT	DATE S.O. ISSUED	DESIGN LABOR	
—DUPLICATE	☐			LABOR	
—REPAIR	☐	ANNUAL	DELIVERY WEEKS	TOTAL LABOR	
—REPLACEMENT	☐			GENERAL EXPENSE	
—ENG. CHANGE	☐	TOTAL EST.	COMPLETED	MATERIAL	
DEVELOPMENT SHOP WORK	☐			TOTAL	
EXPENSE ☐ PLANT INVESTMENT	☐	EST. BY	ACTUAL COST		

DESCRIPTION OF AUTHORIZED TOOL OR WORK

1159

COMPARISON OF VARIOUS METHODS—(ALL FIGURES BARE MATERIAL AND LABOR)

TYPE TOOL OR METHOD	TOOL COST		TOTAL EST. PROD. COST		TOTAL TOOL & PROD. COST	SELECTED METHOD (X)
	MATERIAL	LABOR	MATERIAL	LABOR		

ESTIMATED BY	DATE	APPROVALS		

FF-1031 (rev) 20m 5-14-35

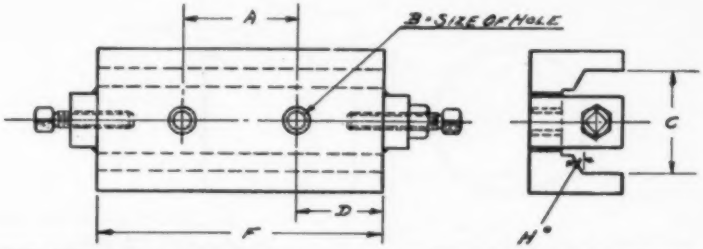
EXHIBIT 1

2. Proper selection of tools cannot be made without information as to the *quantity of parts expected over the total life of the design.* This information is the joint responsibility of the engineering production departments.

Time after time engineers exclaim when asked for such information, "How do I know!" It is true, in many cases, that these figures are but an educated guess at best, but certainly if guessing must be done, the engineer and production man have a much better chance of guessing correctly than the tool department. Not giving the tool department such information or giving them incomplete information, such as quantity on order without stating whether there will be repeat orders, forces the tool department to guess and their chances of error are greater because they do not know the inside story on design and production.

3. Considerable money is lost each year by duplicating tools or through lack of information on existing tools, by making parts slightly smaller or larger where they could be identical with other parts if the designing engineer had the necessary information. Unfortunately, in most cases, both the engineer and tool department are handicapped by having no easy way of finding what tools exist, let us say, to draw a cover of about a certain size. Many plants catalogue their most important families of tools by description and size. Reference to Exhibits 2, 3 and 4 will show the nature of such catalogue sheets, copies of which should be in the hands of the engineer, the planner and the tool department.

4. The planning engineer and tool department should be called into consultation on new designs at the *earliest possible date.* In no case should the engineer wait until completion of the design before doing this. Frequently the practical mechanical ability of these men will give the designing engineer suggestions which will not only result in reduced tool costs, but a better product and possibly lower production costs. We have seen too many cases where, due to the fact that the tool department did not see the drawings until they had been released for production, valuable suggestions could not be carried out without delayed production or excessive costs of necessary changes, all of which could have been saved if the engineer and tool department had been together in the layout stage.



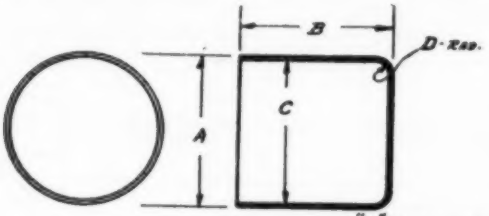
PT.	A	B	C	D	F	H	TOOL No.	PROD. No.	DATE ADDED
1	1 1/4	27/64	2 1/64	15/16	3 1/8	5°	2774007-10	2733464-1	
2	1 1/4	27/64	4 1/64	1	3 1/4	7°	787770-1	2763517	
3	1 1/4	29/64	4 33/64	1 1/16	3 3/4	10°	876138-1A	876138	
4	1 1/4	29/64	6 1/64	7/8	3 11/32	-	2771205-14	1170324	
5									
6	1 1/16	13/32	4 17/64	1	3 1/16	12°	1146	CP 78	
7									
8	1 3/8	27/64	2 1/64	7/8	3 1/8	7°	748203-1	3627260-1	
9	1 3/8	27/64	2 17/64	7/8	3 1/8	6°	2774007-1	2726792-1	
10	1 3/8	13/32	3 1/64	13/16	3	10°	1145	1139202	
11	1 3/8	9/16	3 1/32	3/4	2 7/8	10°	2771205-28	CP 25	
12	1 1/2	5/16	3 33/64	15/16	3 3/16	12°	1066	B16105	
13	1 1/2	5/16	3 17/64	7/8	3 1/8	10°	1149	B16105	
14	1 1/2	27/64	3 33/64	1	3 1/8	15°	2774966-9	4780972-G-2	APR. 3-1936
15	1 1/2	1/16	3 1/64	13/16	3 1/8	8°	1016769-1	292998-G-8	FEB 12 1935
16	1 1/2	1/16	1 63/64	1	3 1/2	9°	784355-1	763831-G-1	
17	1 1/2	27/64	4 1/64	23/32	2 15/16	10°	787745-1	2724042-1	
18	1 1/2	13/32	4 9/64	1 1/4	2 1/2	5°	2774517-1	2733174-1	
19	1 1/2	7/16	4 1/64	1 1/4	4	12°	1143	825128	
20	1 1/2	9/16	4 17/64	1	3 1/2	12°	1146	832175	
21									
22									
23	1.576	27/64	2 3/8	1	3 1/2	8°	2774001-1	2162476-3	

EXCITING POLE PIECE DRILL JIGS

DRAWN BY W. Hunter NOV. 5 1934 INSPECTED BY W. Hunter Nov. 8 1934 K 2771216 MISC.

GENERAL ELECTRIC COMPANY ERIE WORKS M3C1

EXHIBIT #2



"J" THICKNESS-MATERIAL
"K" OPERATION

Pr.	A	B	C	D	J	K	PROD. No.	TOOL No.	DATE ADDED
1									
2	.750	1 35/64		1/32	.015 B	5 Draws	2371759		
3									
4									
5	1.655	-	1.625	3/16	.015 B.	Blk.-Dr.	2702755	788752-1	
6	1.310		1.280	3/16	" "	2nd Draw	"	788753-3-7	
7	1.000		.970	1/8	" "	3rd "	"	788753-4-8	
8	.850		.820	1/16	" "	4th "	"	788753-5-9	
9	.750		.720	1/64	" "	5th "	"	788753-6-10	
10	.750	2 1/16	.720	1/64	" "	6th "	"	788753-	
11	.8125	2 1/16	.783	1/32	" "	Final "	"	788753-21-22	
12									
13									
14	1.655		1.615	3/16	.020 B.	Blk.-Dr.	2702760	788752-1	
15	1.310		1.270	3/16	" "	2nd Dr.	"	788753-11-17	
16	1.000		.960	1/8	" "	3rd "	"	788753-12-18	
17	.850		.810	1/16	" "	4th "	"	788753-8-13	
18	.750		.710	1/64	" "	5th "	"	788753-10-14	
19	.750	2	.710	1/64	" "	6th "	"	788753-	
20									
21									
22									

① Revised Dec. 30/935

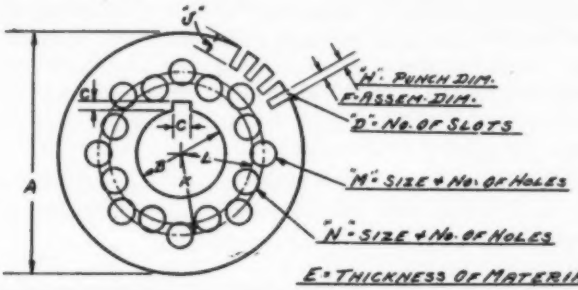
DRAWING DIES - BLD'G. #6

DRAWN BY H. HUNTER JUNE 4-35 INSPECTED BY H. HUNTER JUNE 7-1935 K 2771442

MISC.

GENERAL ELECTRIC COMPANY ERIE WORKS 4549

EXHIBIT #3



Pt.	A	B	C	D	E	F	H	J	K	L	M	N	TOOL No.	PROD. No.	Serial Numb.
1															
2	8 3/4	2 1/4	.498 .265"	25	.025	.378	.385	1.221	2 1/16	1 15/16	3/4-9	3/8-3	1677584-1	1677584-1	
3	8 3/4	2 1/4	.498 .265"	25	.025	.378	.385	1.221	2 1/16	1 15/16	3/4-9	3/8-3	727977-1	1677584-1	
4															
5	10 3/8	2 7/16	.623 .389"	25	.025	.434	.501	1.455	2 3/8	2 3/8	3/4-9	3/8-3	788790	1868459-1	
6	10 3/8	2 3/4	.623 .389"	27	.025	.436	.443	1.965	2 3/4	2 3/4	13/16-9	13/16-3	783942-1	1185672-1	
7															
2 Sets 8	12	3 1/4	.748 .337"	25	.025	.518	.526	1.535	3 1/8	2 5/8	1 1/8-12	1 1/4-9	2162436-2B	2162436-2	
9	12	3 1/4	.748 .337"	25	.025	.518	.526	1.535	3 1/8	2 5/8	1 1/8-12	1 1/4-11	783959-1	2162436-2-3	
10															
3 Sets 11	13 3/4	2 3/8	.623 .388"	35	.025	.513	.520	1.453	3 1/4	2 11/16	1"-12	15/16-12	889956-2D	889956-2	
12	14	3 1/8	1/4	39	.025	.443	.458	1.529	3 1/8	2 11/16	1"-12	15/16-12	885135-2A	885135-2	
13															
14	16	3 1/8	.873 .613"	43	.025	.427	.434	1.660	5 1/16	3 7/16	1 1/8-12	1 1/4-12	1677552-2D	1677552-2	
15															
16	17 3/16	6	.748 .337"	47	.025	.475	.483	1.528	5 5/8	4 1/16	1 1/8-18	1 3/16-16	2779682-1	2726984-2	
17															
18	18 1/2	6 1/4	.873 .397"	35	.025	.715	.723	1.645	5 5/8	4 1/2	1 1/8-18	1 3/16-18	727578-1	2658873-2	
19															

BLANKING DIES FOR ARMATURE PUNCHINGS

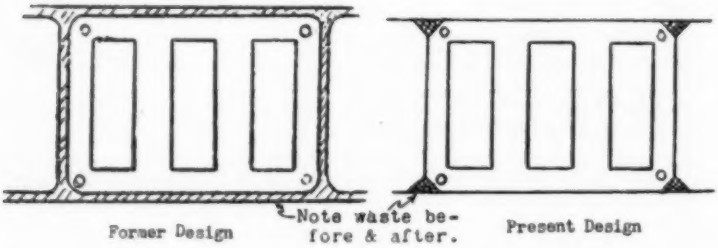
DRAWN BY W. Hunter DEC 27 39 INSPECTED BY W. Hunter Jan. 9, 1935 K 2771285 MISC

GENERAL ELECTRIC COMPANY ERIE WORKS M1A9

EXHIBIT #4

5. A very small change in design may mean a great saving in tool cost. For instance, in the example of the cover our mechanic would have preferred sharp corners and straight edges when he had to make the box by cutting and bending a sheet of metal, but our tool designer likes to have as liberal radi as possible when he has to draw the cover.

Below is an example of what a minor change can accomplish. The shape of a transformer punching was changed as shown in the following sketch.



The engineer was first asked to leave the corners sharp, but when this was found impossible, a compromise was reached in the use of a chamfered rather than a rounded corner. This resulted not only in a lower cost die but in a material saving as well.

6. Encourage your engineers to give as large a tolerance as possible, and to show it on the drawing so that the factory and tool departments know it. Don't mistake this with allowing more tolerance than the design can stand. No one wants that, but they do need everything the engineers can allow them.

7. Closely allied to the above is the entire question of dimensioning drawings. Most companies have standard drafting practices which cover this, which, if followed, would give the desired results. A drawing must convey the thought in the mind of the designer to the factory and tool department without any possibility of error. In a large company we cannot depend upon the tool department knowing where each part goes, its relation to others, how close each dimension must be held, and how much they can take elsewhere. This information must be on the drawing in every case or one of two things will result; either we get some tools made

inaccurately, or we put the tool department in the state of mind that they make everything as *accurately as possible* with the resulting excessive cost.

One of the most troublesome things is the interpretation of fractional dimensions. Most plants usually have practices such as, "It is to be understood by the designer and the manufacturing department that when machined dimensions are given in common fractions, work will be within the following variations:

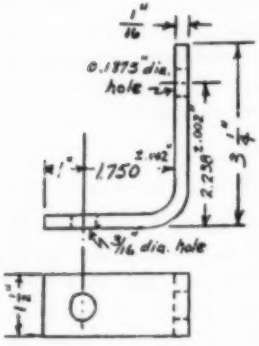
¼" or less—plus or minus 1/128"
Over ¼" —plus or minus 1/64".

If this were followed to the letter we would have very little trouble due to this cause, but numerous cases have been found where engineers have used fractional dimensions when they could never allow the tolerance stated above. In one department, the engineers were questioned as to why they used the fractional dimensions in several cases when they knew they needed the dimensions held within plus or minus 0.002". The surprising answer was that this department thought that where drill jigs or other tools were made for a part, it was unnecessary to show tolerances on fractional dimensions. It was pointed out to them that frequently they have parts on which tools are made and the dimensions need not be held closely at all, and by following their practice they made it impossible for the tool department to tell which part had to be accurate and which did not. As a result, the tool men made everything as accurately as possible. Needless to say, this practice has been changed, but it will take quite a while before the tool department in the particular plant gets to the stage where they will believe the drawings. Exhibit 5 shows a number of examples of incorrect dimensioning practice, the net result of which was to give the factory and tool department the wrong information.

It is difficult to believe that such simple principles are causing so much trouble. The failure to dimension a part so as to correctly indicate the proper relationship of various holes, surfaces, etc., may easily change the entire tooling picture. For instance, in the case of the example given first on Exhibit 5, if the hole had to be held in relationship to the back of the part, it might require the hole to be pierced after forming, as a separate operation, unless the stock could be obtained to very close tolerance on thickness.

EXHIBIT 5

SAMPLES OF POOR DIMENSIONING



Questions a tool designer would ask about this drawing.

Q. What is the difference between the O.1875" and 3/16" holes?

A. None, both are clearance holes.

Q. Why dimension one leg from back of bend and the other from the center-line of the hole?

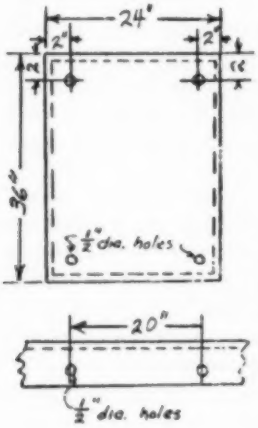
A. Because it was convenient.

Q. Then does the difference in dimensioning in the two cases have any significance?

A. No.

Q. Do you really want the O.1875" hole dimensioned from the back of the bend, or will it be satisfactory to hold this tolerance from the inside of the bend?

A. It was easier to dimension from the outside, but inside is O.K.



This panel is to be mounted by bolts through the ½" holes in panel and steel channel. As dimensioned let us say that the factory made the holes 2"—1/64" from the edge, which is allowed by our drafting practice. In addition our panel was cut full 24" + 1/64". That would give us a dimension of 20" + 3/64" between the holes on the panel.

Then suppose in drilling the channel the holes were spaced 20"—1/64", we would find that the holes in the panel would be 1/16" farther apart than those in the channel, with possible assembly difficulties. The engineer did not care about the relationship of the holes in the panel from the edge, but he did want them to line up with those in the channel. If he had dimensioned the holes from each other the maximum variation would have been 1/32" instead of 1/16".

Low Production Tools

We have indicated earlier in this discussion that theoretically tools are rarely necessities. Actually, however, we find that the production requirements do not have to be very large before we can justify economically an investment in some kind of tools. A large portion of the business in most organizations is distributed over low production devices, which may have productions of a few thousand over the total life of their design. Obviously, on these devices we would like to enjoy all the advantages of complete tooling, but without the expenditure of large sums for tools. At this stage the engineer usually wants some "cheap tools," as he calls them. Such a term gives the impression of shoddiness, inaccuracy and poor workmanship. As such, the use of this term should be discouraged in favor of the description, "low production." Accuracy is just as important in a part made in lots of a hundred as in one made in the millions, and low production tools must be able to produce the identical part that would be made by a high production one.

Types of Low Production Tools

Low production tools fall into two general classes, one in which the production costs of the part are increased, and the other where the production costs remain the same, but the tool is designed to wear out sooner than a high production tool. In addition, some tools are a combination of these two. We will now give a few examples of each type.

A. Increased Production Costs.

(1) The example of the drawn cover given earlier in this paper is one where for the production of 100 covers we made a layout template and a forming die instead of blanking and drawing dies. This equipment, you will remember, gave us a production cost of $5 a cover, compared to the 5¢ cost with the more expensive tools.

(2) Most production departments have what are called "stock dies" with which they can make simple punched parts without special tools. As an example, let us consider a ⅛" thick steel plate, 12" square with a ½" hole in each corner. For high productions you would make a die to punch these four holes at one stroke of

the press. For low production we could use stock dies—just make up a gauge and punch these holes one at a time. Of course, if we have no ½" punch and die we could make one considerably cheaper than a complete die to punch four holes at a time.

(3) Suppose the plate we punched under (2) was two inches thick and the holes ¼" so that we had to drill them. For high production we would probably make a drill jig (plate type) with tool steel bushings. For low production we would make a drilling template from which we could lay out the locations of the holes. The production cost would be greater with the template than with the drill jig.

B. Lower Tool Life but No Change in Production Cost.

(1) For drilling the plate given in "A-3" above, we might make a drill jig without the usual hardened bushings by just taking a piece of cold rolled steel plate and boring holes in the right position and case hardening the plate after inserting a couple of pins to locate the part to be drilled. This would give the same production cost as the high production drill jig with bushings, but the life of such a jig would be quite limited.

(2) The dies for punching the rotor lamination for a high production fractional horsepower motor are at present ¾" thick. This is the maximum thickness found feasible to date, and the dies are capable of punching about 1,500,000 laminations. If, however, we were to have a special motor on which the total estimated production would require only 500,000 punchings, we could make a die about half the above thickness and reduce the length of punches. Such a change would reduce the die cost without in any way affecting the production cost.

C. Combinations of "A" and "B". Lower Life and Higher Production Costs.

(1) "Push-through" types of dies are a recent development. In this type of die the punch parts are loose and are not secured to the ram of the press. Each stroke of the press they must be picked up from below and placed on top of the material in nests which locate them. The press, on being tripped, strikes them and drives them through the material. These dies are usually made of cold rolled or machine steel instead of tool steel and casehardened,

which, of course, limits their life to around 3,000 to 5,000 punchings in steel. In addition, the punching operations are quite slow and production costs high compared to the more costly dies.

When to Choose a Low Production Tool

Many technical articles have been written on various types of low production dies and give some indication of the possible limitations on their use. Generally, however, we can state definitely that there is no "rule of thumb," that can be used in determining the type of tool to select. There is only *one way* to determine correctly the best method:

A. Obtain the best possible estimate of the number of parts needed over the estimated life of the design.

B. Obtain tool estimates on *all* the various methods that can be used.

C. Determine production costs obtainable with these various methods.

D. Take a sheet of paper and do a little arithmetic; multiply the quantity by the production cost obtainable with each method, add to this figure the cost of the tools, and then compare the results with the various methods.

E. Use good judgment in deciding on the method to use. If one method does not figure out as economically as another, but the difference is slight, it might still be advisable to select it, if possible; it might be more fool-proof or less open to damage.

What Other Functions Are Doing to Help Reduce Tool Cost

Although this paper has been devoted to the part the cost accountant plays in controlling tool costs, we feel you will be interested in an outline of the complete picture, together with a brief description of the efforts being made by other functions to aid this work. Exhibit 6 is an outline of the various factors entering into the "Control of Tool Cost." We will now discuss each of the factors not already touched on.

First Cost

A. Production Forecast

We have already discussed the importance of this item and merely wish to point out that surprising as it may seem, efforts are

EXHIBIT 6

CONTROL OF TOOL COST

Elements of Tool Cost	*Factors Contributing*	*Responsibility*
1. FIRST COST		
A. Production Forecast		Production Dept. Engineering Dept. Commercial Dept
B. Selection of Method of Manufacture		Engineering Dept. Manufacturing Dept. Tool Division
C. Tool Design		Tool Division
D. Manufacturing Limits on Pieces to be Produced		Engineering Dept.
E. Method of Producing Tools		Tool Division
F. Machine Equipment for Use of Tool -1-1-		Manufacturing Dept. Tool Division
G. Ordering of Tools		Manufacturing Dept. Engineering Dept.
H. Engineering Changes		Engineering Dept.
2. MAINTENANCE		
A. Quality of Work Produced		Tool Division
B. Tool Service Ability		Engineering Dept. Tool Division
C. Tool Cost per Piece Produced		Manufacturing Dept. Tool Division
D. Pieces per Set-Up		Production Dept. Manufacturing Dept. Commercial Dept.
E. Care of Tools		Manufacturing Dept.
F. Condition of Mfg. Equipment		Manufacturing Dept.
G. Selection of Lubricants		Works Laboratory Manufacturing Dept. Engineering Dept. Tool Division
H. Actual Repairing Cost		Tool Division
3. OPERATING PRACTICE		
A. Production Cost per Piece		Manufacturing Dept. Tool Division
B. Use of Tools		Manufacturing Dept. Tool Division

usually only partially successfully in obtaining this necessary information. It is a good practice to instruct your tool room to turn back all tool requests which do not contain complete quantity information.

B. Selection of Method of Manufacture

This, of course, determines the general type of tool to be made and has already been discussed.

C. Tool Design

In recent years, more than the usual amount of attention has been paid to the possibility of tool cost reduction through better materials and simplified designs. We have come to think of tool design and manufacture as being very similar to any other form of special, low production manufacture. As such, it can be attacked in very much the same fashion as for production devices. Of course, only high spots can be touched and general principles of design modified. Although we rarely rebuild the *same* tool, we are continually building similar tools, so the method of attack has been to study sample tools for possibilities of savings and then set up general principles. Below are just a few of the changes recently made by some tool departments to reduce tool costs.

1. Use of special cast iron for drawing dies.
2. Use of machine steel in place of tool steel for certain types of forming dies.
3. Use of free machining steels for Bakelite and Textolite molds.
4. Large piercing and trimming dies usually were sunk into castings or had welded-on backing-up bars to prevent shifting of sections. In many cases this has now been replaced by the use of dowel pins to prevent this shifting. This has eliminated expensive machining and fitting, as well as material. (See Exhibit 7).
5. Use of standardized drill bushings, thumb screws, handles, cams, die sets, guide pins, etc. This has reduced design labor and made possible manufacture of these parts in quantities or purchase from suppliers of such standard parts.

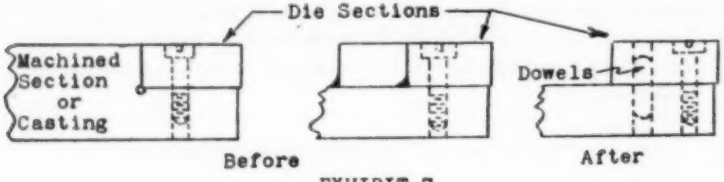


EXHIBIT 7

D. Manufacturing Limits on Pieces to Be Produced

Previously Discussed.

E. Method of Producing Tools

(1) *Specialization*

At one time an individual toolmaker would make a complete tool or die. Then, as delivery dates became shorter and pressure for reduced costs was applied, we found each toolmaker having one or more less skilled helpers assigned to him to do the unimportant work. Today we find more and more the tendency towards "specialization," that is, the use of machine operators on the various machines to make the parts of a tool which the toolmaker will fit and assemble to make the completed die or fixture. The advantages of such a setup are:

(a) Ability to use more men on a given piece of work and thereby speed delivery dates.

(b) Ability to use less skilled operators by training them in the use of one machine instead of many.

(c) Greater speed and ability developed by an operator when working constantly on one machine instead of many, and better care of such machines when under the responsibility of one operator.

On the other hand, the disadvantages of this setup are:

(a) Need of more complete drawings when many people work on a given tool.

(b) Difficulty, especially in small tool rooms, of balancing loads and keeping operators busy on individual machines.

(2) *Planning Operations*

Instead of each toolmaker selecting the method most suitable to him for making a given tool, we find some tool shops going over

to the use of operation planners, who determine the most economical method of doing the work and set up standards to measure the output of the shop.

In addition to the above general methods of reducing tool manufacturing cost, tool shops, like all manufacturing departments, are finding ways to increase machining and grinding speeds, using machine tapping more extensively, extending the use of cutting lubricants on machines, etc.

F. Machine Equipment for Use of Tool

The type of machine equipment used in conjunction with a given tool often has a great effect upon the type of tool required and its cost. For instance, on punched parts, some departments do not have slitting or shearing facilities for accurately cutting the material in strips before entering it into dies. As a result, this may change a simple cut-off die to one which must blank the part all around to insure accuracy of the finished part.

G. Ordering of Tools

A very important change that has recently been inaugurated is the setting up of the tool department as a unit cost department which may take certain classes of work on the basis of "firm billing prices." Previously, if an engineer obtained an estimate from the tool shop, it was no assurance at all that the tool would not cost him several times the estimated amount. Under the new setup the tool department will bill such estimated amounts, unless work is requested other than that on which the tool department quoted. Each tool department has its own "profit and loss" account, and as such it is expected that they will feel a greater responsibility for meeting their estimates and reducing these costs.

H. Engineering Changes

No portion of a tool cost is as valueless as that caused by engineering changes. Generally, all we can say is that this money was spent to correct someone's error or poor judgment. Of course, all such losses cannot be eliminated; hindsight is always better than foresight. But we must do all in our power to minimize such losses. The judicious use of models is a great help, but as has been pointed out earlier, such models should be gone over with

your factory and tool designers to get the greatest benefit from them.

Models themselves cause great losses in many cases. We forget sometimes that a part for a model made by hand cannot always be produced by a tool. In addition, it is always difficult to keep trained model makers from "making" a model work, that is, bending a part, or filing a hole larger without telling the engineer about such changes so that he may bring his drawings up to date.

To correct this condition, one plant we know of has adopted the practice of having the assembly of such models made by regular assemblers rather than skilled model workers. They work on the theory that unskilled assemblers would not know how to correct difficulties and as such the engineer would know if changes are necessary.

Maintenance

A very large part of most plants' expenditures for engineering tools and maintenance is spent for the latter part. Frequently they spend almost as much for repairing and replacing tools and patterns as they do for making new ones. This problem is very difficult, particularly because of the numerous factors which affect maintenance of tools. Let us consider the most important.

A. Quality of Work Produced

A tool may give the required accuracy or fineness of finish when it is new but as it wears, rejections may increase and then comes a point where we must either repair or replace the tool. Better materials, better workmanship and better design are, of course, the answer to this.

B. Tool Service Ability

A tool may give long life and continued accuracy, but may be subject to frequent breakdowns, which not only cost money for repairs but hinder production and usually increase production costs. One answer, of course, is again better material, design and workmanship in the tool division. The engineer may also help. For instance, larger punches are always stronger and harder to break than small ones.

C. Tool Cost per Piece Produced

This is, of course, a measure of the economy of a tool; remember to distinguish between a cheap tool and an economical one.

D. Pieces per Setup

In the case of punches and dies, every setup represents a hazard, a chance to shear or ruin the die. As such it is highly desirable to have production order quantities agree as nearly as possible with the number of parts obtainable per die grind, or else a multiple of this number. As this quantity fluctuates in most cases, it is quite difficult to make a practical arrangement to bring this about, but wherever possible it should be done. For instance, if 50,000 parts are desired for stock and the die runs dull at 45,000, obviously to reset the die for the balance of 5,000 pieces is costly and it would be desirable, where possible, to hold up the balance until the next order.

E. Care of Tools

This includes the education of the operators, setup men, and foremen in the use and care of their tools. Insufficient work has been done along these lines. Sturdy clamps should be on all presses so as to securely hold dies without shifting. Periodic surveys by the tool room supervisors should be made, so as to point out any need for improvement.

F. Condition of Manufacturing Equipment

Spindles running out-of-line on a drill press or improperly conditioned punch presses take considerable life out of tools and should be checked regularly. Studies should be made to compare die life obtainable with identical dies on different punch presses. The results obtained point the way towards better equipment.

G. Selection of Lubricants

Considerable work has been done by the large oil companies along this line and their results are available to their customers.

H. Actual Repairing Cost

Many plants have sacrificed control over their maintenance costs by having charges made against master accounts which, because of

their generality, make it impossible to tell where and for what the money is being spent. It is true that most repair charges run under $15, and therefore cannot individually be handled as carefully as an order for a new tool. It is well to consider whether you should accumulate your repair costs by individual tools or at least classes of tools, so that high spots may be studied.

Operating Practice

As has been pointed out earlier in this discussion, the main reason for tools is to reduce production cost, and as such we have listed it as a factor under tool cost.

A. Use of Tools

The design of all tools should be approved by the manufacturing department to insure that it will be satisfactory when completed. Frequently tools have been discarded or remade because of an unsatisfactory clamp or loading device which made them unhandy to use.

Conclusion

In this discussion we have not attempted to point out the things that your engineer should or should not do in his designs to obtain low tool cost. Many of the more important things have been discussed in technical articles on this subject. However, experience and close association with the factory and tool specialists are necessary before a designer can master this phase of his work. The tool specialists are glad to offer assistance and discuss proposed designs with him.

As a cost accountant it is your responsibility to encourage complete co-operation, for only then can you expect to obtain good tools at the lowest possible cost.

You must furnish the operating departments with current and accurate cost details, and educate them in their use. Above all, insist upon at least a rough financial justification before approving any tool expenditure.

Convention News

Trade Association Activities in the Spotlight

On April 23, 1940 there was entered in the U. S. District Court for the Southern District of New York a consent decree involving the National Container Association and several companies manufacturing corrugated and solid fiber containers which, according to trade association lawyers and executives, does more to clarify permissable fields of trade association activities under the anti-trust laws than anything which has occurred since the passage of these laws.

The importance of this decree to N. A. C. A. members arises from the fact that on Thursday, June 27, at the National Convention in St. Louis an entire day is to be devoted to a consideration of co-operative industry efforts in the development of sound cost practices, cost education work and the circulation of cost information. With this decree providing a clarification with respect to trade association activities in the cost field, it is felt that this session will be of special significance at this time, and provide the stimulus for additional cost activity by trade associations in fields covered by the decree.

The Convention Program Committee has been fortunate in securing as lead-off speaker for Thursday's session, Dr. Corwin Edwards, Special Assistant to the Attorney General, who is at present Director of the housing investigation in the Anti-Trust Division of the Department of Justice. Dr. Edwards will discuss "What is Possible Under Present Law and Government Attitude?" at the Thursday morning session, and will be followed at the afternoon session by speakers who will present "Industry's Viewpoint and Actual Practice." The viewpoint of the trade association executive will be presented by Mr. Earl Constantine, President of the National Association of Hosiery Manufacturers, who is also President of American Trade Association Executives. Following the presentation of industry's view point by a leading industrial executive, the three speakers will constitute a panel for further discussion of the problems arising from co-operative industry activities in the cost field.

Further Convention information will be found on the back cover of this Section.

ANNUAL COST CONFERENCE

St. Louis

June 24 - 25 - 26 - 27

Note These Interesting Plant Visitations

ANHEUSER-BUSCH BREWERY—manufacturers of the famous "Budweiser" beer.

OWENS-ILLINOIS GLASS CO.—manufacturers of glass bottles.

WAGNER ELECTRIC COMPANY—manufacturers of electric motors, transformers, etc.

KNAPP-MONARCH COMPANY—manufacturers of a large line of electric appliances.

* * *

AMERICAN WINE COMPANY—manufacturers of choice wines and Cook's Imperial Champagne.
(Ladies Only)

More details and pictures will be published in the Pre-convention issue of the Convention Daily News

See page 1177 *for further Convention News*